N71-22623

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RESULTS AND ANALYSIS OF A COMBINED AERIAL AND GROUND ULTRAHIGH-FREQUENCY NOISE SURVEY IN AN URBAN AREA

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION • WASHINGTON, D. C. • APRIL 1971

1. Report No. NASA TM X-2244	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle RESULTS AND ANALYSIS OF A COMBINED AERIAL AND GROUND ULTRAHIGH-FREQUENCY NOISE SURVEY IN AN URBAN AREA		5. Report Date April 1971
		6. Performing Organization Code
7. Author(s) Godfrey Anzic and Charlene May		8. Performing Organization Report No. E-6002
		10. Work Unit No. 164-21
9. Performing Organization Name and Address Lewis Research Center National Aeronautics and Space Administration Cleveland, Ohio 44135		11. Contract or Grant No.
		13. Type of Report and Period Covered Technical Memorandum
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D. C. 20546		14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

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17. Key Words (Suggested by Author(s))		18. Distribution Statement
UHF noise Man-made radiofrequency rf noise rf noise rf noise survey	Urban rf noise rf interference Indigenous urban rf noise rf noise recording system	Unclassified - unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
Unclassified	Unclassified	37	$3.00

*For sale by the National Technical Information Service, Springfield, Virginia 22151

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SUMMARY

The results of a combined aerial and ground survey of radiofrequency noise in Phoenix, Arizona, are presented. The measurements were made at 0.3, 1.0, and 3.0 gigahertz.

The rms noise level and the average noise envelope voltage were measured. Ten 3-decibel (dB) step comparators were also used to provide data on noise amplitude distributions. Simultaneous air measurements were made while conducting the ground measurements. The air and ground rf noise measuring systems were essentially the same. The primary objectives of the survey were to determine the correlation between air and ground noise data and to demonstrate the ability to identify high urban noise areas from aerial data.

The survey was performed by the contractor, General Dynamics/Convair Division. All data reduction and correlation calculations were made at NASA Lewis Research Center. Due to the very large quantity of data obtained during the survey, a computer was used to reduce the data to usable numbers and plots.

The results of the survey indicate that identification of high urban rf noise areas can be accomplished from aerial data. Good correlation between simultaneous air and ground noise data was obtained for properly selected ground sites. Typical noise observed was impulsive and random and exhibited a high peak-to-rms ratio. It is estimated that an aerial survey of an urban area can be performed in 5 to 10 percent of the time required for a ground survey.

INTRODUCTION

The ultrahigh radiofrequency spectrum (UHF) presents a region where a space-to-earth communication system is feasible and attractive technologically. However, radiofrequency noise poses a major problem in the design of such communication systems intended to serve large areas. Considerable effort must be expended to recover the original signal once it has been degraded by the addition of numerous interfering signals. Since rf noise is associated with human activity, urban areas normally exhibit high noise levels. Knowledge of rf noise levels in urban and other inhabited areas must be obtained if a system serving a large area with many receiving terminals is to be designed effectively. The available man-made noise data for this frequency region is nominal and outdated.

Radiofrequency noise or interference (RFI) is generally considered to be either coherent or incoherent. Emissions from radar, communication systems, etc., are considered to be coherent, while indigenous man-made noise such as that generated by ignition systems and other types of electrical machinery is considered to be incoherent. The investigation of incoherent noise, typically impulsive and random in nature, is presented in this report.

Most previous rf noise investigations were conducted by measuring noise at different ground locations. This task is expensive and time consuming. Since for our purpose the definition of only high noise areas is required, a quick and inexpensive method of surveying large urban areas is desirable. An aerial survey is economically attractive and promises a quick way to obtain the desired data. However, to make such a survey useful, the ability to identify high urban noise areas from airborne data must be demonstrated and the correlation between ground and air noise levels must be obtained.

This report presents the results of a combined aerial and ground rf noise survey conducted in the city of Phoenix, Arizona, during the summer of 1968. The survey was conducted by General Dynamics/Convair Division under contract for NASA. Details of measurements taken during the survey are given in the contractor's final report (ref. 1). All data were reduced at NASA Lewis Research Center. The survey was performed as part of the space-to-earth communication technology evaluation.

EQUIPMENT AND PROCEDURE

Ground Survey

Since the RFI in the upper region of the UHF spectrum is relatively unexplored, radiofrequency noise was measured in clear channels at or near 0.3, 1.0, and 3.0 gigahertz. The receiving system, housed in a shielded and generator-equipped van, consisted of three low-noise (noise figure <4 dB) solid-state receivers (fig. 1(a)). A data processing and recording system (fig. 1(b)) conditioned the basic noise data into desired parameters and supplied the necessary coding information for tape recording.

Ground noise data was measured as a function of antenna azimuth, polarization, elevation above the horizon, and time of day.

Six antennas, mounted on a 40-foot (12-m) collapsible tower, were used to receive rf noise. The characteristics of the antennas were as follows:

Frequency, GHz	Type of antenna	Gain, dBi	Polarization
0.3	Quad dipole	11	Circular
.3	Corner reflector	10	Vertical or horizontal
1.0	Helical	11	Circular
1.0	Horn	9	Vertical or horizontal
3.0	Helical	13	Circular
3.0	Horn	19	Vertical or horizontal

Six locations, on or near the flightpaths which cross the city hub, were selected as noise measuring sites (fig. 2). In order to avoid near-field noise sources, the measuring sites were a reasonable distance from homes, high buildings, and power lines, as shown in figure 3. Photographs taken of each site and the surrounding area were used for site characterization during the data reduction.

Noise data was collected by a periodic sampling of rf noise at each of three frequencies. A sequencer controlled the period of measurement at each frequency. In order to observe the daily urban noise variation, all recording was done during three time periods:

(1) Morning (0630 to 0830 hr - rush hour)

(2) Noon (1000 to 1200 hr)

(3) Evening (2000 to 2200 hr - post rush hour)

No measurements were made on weekends.

To properly characterize the noise and its effect on wideband channels, a noise bandwidth of 2.7 megahertz was used in all three survey channels. The noise parameters measured were rms noise, average noise envelope, 60-hertz noise component, and 15.75-kilohertz noise component.

Ten 3-dB-step comparators were also used to provide data on noise amplitude distributions, pulse width, and frequency of occurrence.

Aerial Survey

A DC-3 aircraft, equipped with an interference-suppressed ignition system and suitable electrical power generators, was used in the aerial survey. An air speed of

100±10 knots (185±18 km/hr), at altitudes of 1000 and 4000 feet (305 and 1220 m), was used for all survey flights. The aircraft, frequently used in scientific experiments of similar nature, proved ideal for this task, since the pilots were familiar with precise flying requirements.

The receiving system used for the airborne survey was essentially the same as the ground system, except that only circularly polarized antennas were used. The antennas were mounted on removable panels on the underside of the aircraft fuselage (figs. 4 and 5).

Five parallel paths were flown over the city. One path was also flown normal to these paths passing over the center of the city (fig. 6). Simultaneous ground measurements were made at three ground locations while conducting the air measurements. Like the ground measurements, the air measurements were also made during morning, noon, and evening hours. An automatic sequence camera was used to provide the photographic record of ground area covered by the antenna pattern. The sequence photographs were used for noise source identification and air data correction factor calculation.

Data Reduction

Recording format. - The rf noise data, conditioned into the desired parameters (e.g., rms noise, average noise envelope, etc.) by the data processing system was recorded on magnetic tape in the format shown in figure 7. A logic system, driven by a 100-hertz clock, advanced the receiving system sequentially through three rf channels at a rate of 3 seconds per channel. A diode function generator scheme was used to compute the rms value of noise, which was averaged over a 300-millisecond period. The average noise envelope was rf noise averaged over a 100-millisecond time period. Phase lock voltmeters were used to provide the 60-hertz and 15.75-kilohertz noise component values.

Ten amplitude comparators, set to the levels shown in table I, provided data on noise amplitude distribution and frequency of occurrence. Two integrators were associated with each comparator. The first integrator's output was directly proportional to the amount of time the noise exceeded the particular comparator level (time integrator). A second integrator, whose output was directly proportional to the number of times the noise level exceeded the comparator threshold, provided data on frequency of occurrence of noise pulses (events integrator).

Code channels, identifying frequency, time/events integrators, antenna orientation, and other pertinent information were also recorded on magnetic tape to facilitate data reduction. All data channels were calibrated by introducing voltages corresponding to 0 and 100 percent of full-scale deflection into each data channel. A 50-kilohertz reference frequency, also recorded on magnetic tape, served to correct any data errors introduced by recorder speed variations.

Computer data processing. - Initial airborne and ground noise survey data tape processing included addition of time code and digitizing an average of 15 coding and data channels from each survey tape. In order to conserve computer time and the amount of tape generated by the digitizer, the lowest usable digitizing rate was used. Since 10 channels of comparator data (time/events integrators) were recorded in proportion to the amplitude of a 150-millisecond-wide pulse, proper data reduction of these channels limited the choice of the digitizing rate. After an unsuccessful attempt to properly retrieve the comparator data from a tape digitized at a rate of 1 kilohertz (data sample every 15 msec), the next available rate of 4 kilohertz was employed. In this case, the data were sampled approximately every 4 milliseconds. Unlike the first case, the sample rate here was sufficient for the computer to properly identify the code channel pulse levels when the time and events integrators were to be sampled. Plots of amplitude against time were generated for both time and events integrator data at each comparator level.

A 3-second sample of rf noise at each of the three survey frequencies was available to the computer. Controlled by the frequency code channel, the rms data were sampled and averaged only during the middle second. Data during the first and third seconds were rejected because of possible errors due to system rise time and switching transients.

All aerial rms noise and comparator data were plotted by the computer as a function of time for each flightpath. Similarly, all rf noise data recorded at various ground sites were also plotted on microfilm as a function of time. In addition to microfilm plots, the ground rms noise data were also sorted and printed out as a function of frequency, antenna azimuth, antenna polarization, and antenna elevation.

Data compensation. - The 50-kilohertz reference frequency, recorded on the magnetic tape along with data and coding channels, served to compensate any errors introduced by tape recorder speed variations. Normal data compensation during the initial phase of data reduction could not be accomplished, because the playback recorder was limited to only two tracks of data compensation. Since the survey recording format utilized four tape tracks, and significant errors were encountered without compensation, all data were compensated during the computer phase of data reduction. It can be shown that from a basic relation of

$$\frac{f_i}{f_o} = \frac{f_i'}{f_r} \tag{1}$$

where

f_i true frequency, any data channel

f_o reference frequency for zero error (50 kHz)

f_i' detected frequency, any data channel

f_r detected reference frequency

the final data compensation relation can be calculated to be

$$S_i = S_i' - S_r\left(\frac{f_{io}}{f_o}\right)\left(\frac{V_{fs} - V_o}{f_l - f_u}\right)_i\left(\frac{f_l - f_u}{V_{fs} - V_o}\right)_r \tag{2}$$

where

S_i	true signal voltage
S_i'	detected signal voltage
S_r	reference channel voltage
f_o	reference channel center frequency (50 000 Hz)
f_{lr}	reference channel lower band edge (46 250 Hz)
f_{ur}	reference channel upper band edge (53 750 Hz)
f_r	detected frequency, reference channel
f_{io}	detected frequency, any data channel
f_{li}	data channel lower-band-edge frequency
f_{ui}	data channel upper-band-edge frequency
$(V_{fs}, V_o)_i$	full-scale and zero calibration voltages for any data channel
$(V_{fs}, V_o)_r$	full-scale and zero calibration voltages for reference channel

Since all the defined parameters are known, the true signal voltage S_i for any data channel was easily obtained.

RESULTS AND DISCUSSION

Ground Data

A typical example of rms noise data from the ground survey is shown in table II. The rms noise voltage, the parameter most commonly used in noise calculations, expressed in dB above KTB (where K is Boltzmann's constant, T is 290 K, and B is receiver bandwidth) is presented as a function of time of day. Noise data were found to be insensitive to antenna polarization; therefore, the noise levels presented are the average noise levels received with the antennas of three different polarizations.

The results from only three ground recording sites are presented. These sites were selected as typical of the total of six where the rf noise was measured. Site 1 was located in a downtown area, site 3 in the industrial outskirts of the city, and site 10 was adjacent to an interstate highway in the older section of the city. Typical noise levels obtained at these ground sites confirm the fact that the daily cyclic nature of rf noise is directly dependent on human activity. Normally, the highest noise levels were recorded during the rush hour. Although noise recordings were only made during the morning rush hour (0630 to 0830 hrs), it is assumed that similar noise levels occur during the evening rush hour (1600 to 1800 hrs). The average rush hour rms noise levels recorded were 11 and 6 dB above KTB for 0.3 and 1.0 GHz, respectively. Average noon hour noise levels were approximately equal to the rush hour levels. Late evening noise levels were 4 to 6 dB below the rush hour levels. Typical noise predominating in most cases was caused by the automobile ignition systems. Similar observations were made during an earlier rf noise survey conducted in Cleveland, Ohio, in 1967 (ref. 2).

A sample of microfilm data of rms, average noise envelope, and time comparator levels recorded at site 10 are presented in figure 8. No events comparator data are presented because of the improper scaling employed during the survey. Subsequent investigation into the events comparator scaling revealed that the typical number of noise pulses recorded at 0.3 gigahertz ranges from near 7000 per 3 seconds for the first comparator (near receiver threshold) to 1500 per 3 seconds for the 10th comparator (30 dB above receiver threshold). The events integrator scaling as presented in table I resulted in a full-scale output for all 10 integrators which yielded little usable data.

Phaselock voltmeters, employed to sample the noise components related to the television synchronizing frequencies, indicated that insignificant 60-hertz and almost no 15.75-kilohertz noise component levels existed in the general urban UHF rf noise environment. No 3-gigahertz data are presented since most data obtained are questionable because of receiving system limitations. The small quantity of valid data obtained indicates that the rf noise was near the system threshold for the majority of the time (<4 dB above KTB).

Aerial Data

An airborne antenna surveys a considerably larger area than a ground antenna. Although a ground antenna gives adequate information about the noise environment of a specific area, an airborne antenna supplies only limited time-varying noise information of a particular area. This is due to the considerably shorter time during which an area's noise is measured from an aircraft. An aerial survey, therefore, provides a better knowledge of a general noise environment of a larger area than a ground survey. Figures 9(a) and (b) show the area covered by aerial antennas' half-power beamwidths from the survey altitudes of 1000 and 4000 feet (305 and 1220 m). The majority of the rf noise data were taken from the 4000-foot (1220-m) altitude, although some noise data were also recorded from the 1000- and 10 000-foot (305- and 3050-m) altitudes. The analysis of the data revealed that no useful correlation could be obtained between ground noise and data taken from 10 000 feet (3050 m) altitude due to an extremely large difference between the two areas "seen" by the survey antennas. Radiofrequency noise data obtained at a 1000-foot (305-m) altitude proved to be somewhat too selective of noise sources because of the antenna's narrower coverage pattern. An additional problem of aircraft stability at this low altitude and speed forced the adoption of 4000 feet (1220 m) as the optimum survey altitude.

The 0.3- and 1.0-gigahertz rms noise profiles of the city of Phoenix, Arizona, are shown in figure 10. Data presented show the typical daily cyclic variation of rf noise also exhibited by data recorded during the ground survey. High urban noise areas are easily identified from aerial data. High noise areas were typically recorded over downtown areas (fig. 11(a)), over the electric power distribution station (fig. 11(b)), and over major road intersections (fig. 11(c)). The noise probability distributions for all airborne data at 0.3 and 1.0 gigahertz are shown in figure 12. Typical 1.0 gigahertz noise levels during rush hour were 5 to 6 dB below the 0.3-gigahertz values. As it was evidenced during the ground survey, the rf noise recorded during the aerial survey also exhibited a very high peak-to-rms ratio. Figures 13 and 14 present the rms noise with its corresponding time integrator traces at comparator levels ranging in noise power from 6 to 35 dB above KTB. Both 0.3- and 1.0-gigahertz data indicate that the peak-to-rms ratio for rf noise is approximately 10 dB.

Air-Ground Noise Correlation

As shown in figure 15(a), the ground system received noise from the following sources: sky T_s, ground T_g, the receiver itself T_r, and the indigenous noise sources T_i, in the subtended angle θ. Figure 15(b) presents the weighting factor G_i which was calculated from the integration of the antenna gain as a function of angle θ subtended by the noise sources. Angle θ was estimated from the photographs taken at each ground site. The noise temperature received at a ground site T_{gr}, with the antenna at 0^o elevation, can be expressed as

$$T_{gr} = 0.5\ T_s + 0.5\ T_g + T_r + G_i T_i \tag{3}$$

The noise power received by the airborne system is shown in figure 16. The airborne noise temperature T_{ar} consists of the ground temperature T_g, receiver system temperature T_r, and the indigenous noise temperature T_i. The weighting factor A_i, representing the percentage of ground area covered by indigenous noise sources (area of human activity), was selected from the examination of aerial photographs. The noise temperature received by the airborne antenna is

$$T_{ar} = 1.0\ T_g + A_i T_i + T_r \tag{4}$$

Assuming that T_g, T_s, and T_r are negligible in most cases, equations (3) and (4) yield the following correlation expression:

$$\frac{T_{ar}}{T_{gr}} \cong \frac{A_i}{G_i} \tag{5}$$

As an example, the correlation data for two ground sites are presented in table III. It is evident that the aircraft altitude and ground site selection greatly affect the degree of correlation. Noise data collected at a 1000-foot (305-m) altitude tend to correlate better with the ground data since the aircraft antenna becomes more selective of noise sources in its narrower coverage pattern. Results of the air and ground noise data correlation for 0.3 and 1.0 gigahertz are shown in figures 17(a) and (b). As shown, only a limited number of simultaneous data points were taken. Assuming that rf noise levels follow a definite daily pattern, a number of other correlations between aerial and ground noise were made if the two readings were recorded within the same hour of the day. A wide variation in correlation data obtained at the 0.3- and 1.0-gigahertz frequencies can be attributed also to the time-varying nature of noise. The air-ground correlation data indicate that an estimate of the ground noise levels can be obtained by subtracting 5 to 7 dB from the noise levels obtained at a 4000-foot (1220-m) altitude.

Figure 18 shows the aerial and ground photography employed for site definition. The site shown in figure 18(a) is the downtown area where good air-ground noise correlation was obtained. The noise-subtended antenna angles were large compared to the site shown in figure 18(b), where poor correlation was obtained. Poor air-ground noise correlation generally resulted where the ground antenna was situated a considerable distance away from possible indigenous noise sources. One example of such a site is shown in figure 18(b), where the airborne antenna obviously surveyed noise sources that were not "seen" by the ground antenna. The ground site shown in figure 18(c), where the ground antenna was immersed in a relatively constant noise environment, yielded good correlation data.

SUMMARY OF RESULTS

A combined aerial and ground radiofrequency noise survey was conducted in the Phoenix, Arizona, area during the summer of 1968. The objectives of the survey were to demonstrate the ability to identify high urban rf noise areas from aerial data and to determine the correlation between aerial and ground data. The following results were obtained:

1. It is estimated that an aerial survey of an urban area can be performed in 5 to 10 percent of the time necessary for a ground survey (ref. 1). Even though the hourly cost of the Phoenix, Arizona, aerial survey was approximately three times that of the ground survey, its cost-time product is still one-third that of the ground effort.

2. An aerial survey can be used to quickly identify high urban noise areas.

3. Cyclic behavior of noise is easily determined from air data in a fraction of the time required to obtain the same result from ground data.

4. The ground noise levels are 5 to 7 dB below noise levels obtained at a 4000-foot (1220-m) altitude.

5. Ground sites well immersed in noise yielded good correlation with air data, while poor correlation was generally obtained with ground sites well removed from human activity.

6. Typical ground rms 0.3-gigahertz noise levels at rush hour and late evening were 11 and 6 dB above KTB, respectively. One-gigahertz noise levels were 5 to 6 dB below the 0.3-gigahertz values. A small amount of valid 3.0-gigahertz noise data obtained shows it to be below receiver threshold (<4 dB above KTB).

Lewis Research Center,
National Aeronautics and Space Administration,
Cleveland, Ohio, November 27, 1970,
164-21.

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1. Mills, A. H.: Measurement and Analysis of Radio Frequency Noise in Urban Suburban, and Rural Areas. Rep. GDC-AWV68-001, General Dynamics/Convair (NASA CR-72490), Feb. 1, 1969.

2. Anzic, Godfrey: Radiofrequency Noise Measurements in Urban Areas at 480 and 950 Megahertz. NASA TM X-1972, 1970.

TABLE I. - COMPARATOR AND TIME/EVENTS INTEGRATOR SETTINGS

Comparator number	Turnon level		Time on 3-second interval to cause 100-percent integrator output, percent	Number of pulses for 100-percent integrator output	Minimum pulse separation for recognition, μsec
	dBm	dB above KTB			
1	-104	6	100	3000	3.5
2	-101	9	↓	3000	↓
3	-98	12	↓	3000	↓
4	-95	15	↓	1000	↓
5	-92	18	↓	1000	↓
6	-89	21	↓	500	↓
7	-86	24	50	500	↓
8	-83	27	50	100	35
9	-80	30	25	50	35
10	-77	33	25	50	35

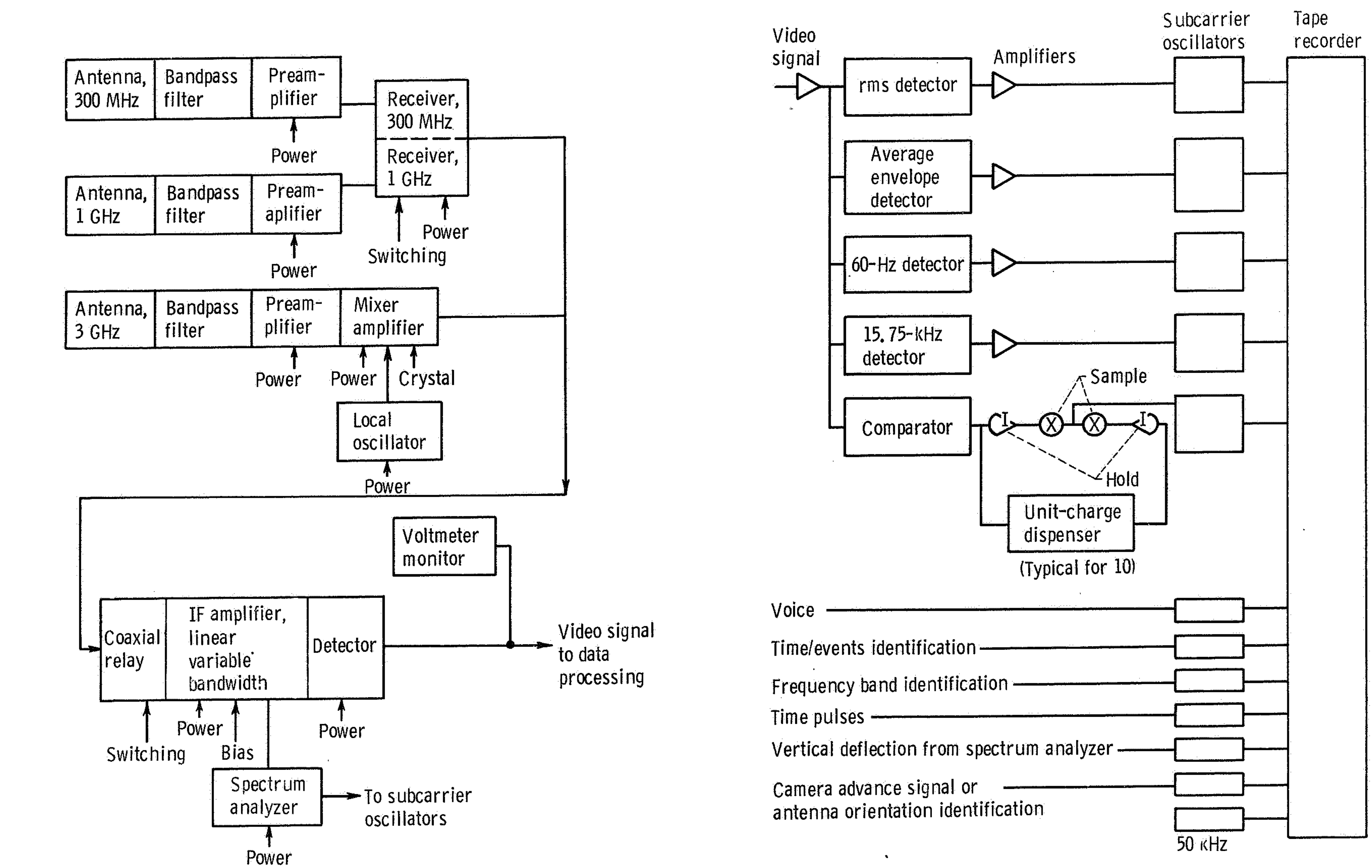
TABLE II. - AVERAGE DAILY RADIOFREQUENCY NOISE LEVELS AT SITES 1, 3, AND 10

Time of day	Frequency, 0.3 GHz				Frequency, 1.0 GHz			
	Site							
	1	3	10	Average	1	3	10	Average
	Average rms noise level, dB above KTB							
Morning (0630 to 0830 hr)	9	6	14	11	7	4	8	6
Noon (1000 to 1200 hr)	10	13	11	11	8	9	5	7
Evening (2000 to 2200 hr)	6	5	6	6	6	<4	<4	4

TABLE III. - SAMPLE AIR-GROUND NOISE CORRELATION

[Frequency, 300 MHz; bandwidth, 2.5 MHz]

	Ground site			
	Site 3, open field		Site 10, near highway	
	Aircraft altitude, ft (m)			
	4000 (1220)		1000 (305)	
	Airborne noise temperature, T_{ar}, dBm			
	-89±2		-92±2	
	Ground antenna azimuth			
	North	East	South	East
Noise temperature at ground site, T_{gr}, dBm	-102±2	-102.5±2	-97±2	-98±2
Weighting factor, A_i, dB	-1	-1	0	0
Weighting factor, G_i, dB	-8	-10	-3.5	-5
Ratio of airborne noise temperature to ground noise temperature, T_{ar}/T_{gr}, dB:				
Calculated	7	9	3.5	5
Experimental	13	13.5	4.5	5.5
Subtended angle, θ, deg	10	5	45	25



(a) Receiving system.

(b) Data processing and recording subsystem.

Figure 1. - Radiofrequency noise recording system. (From ref. 1.)

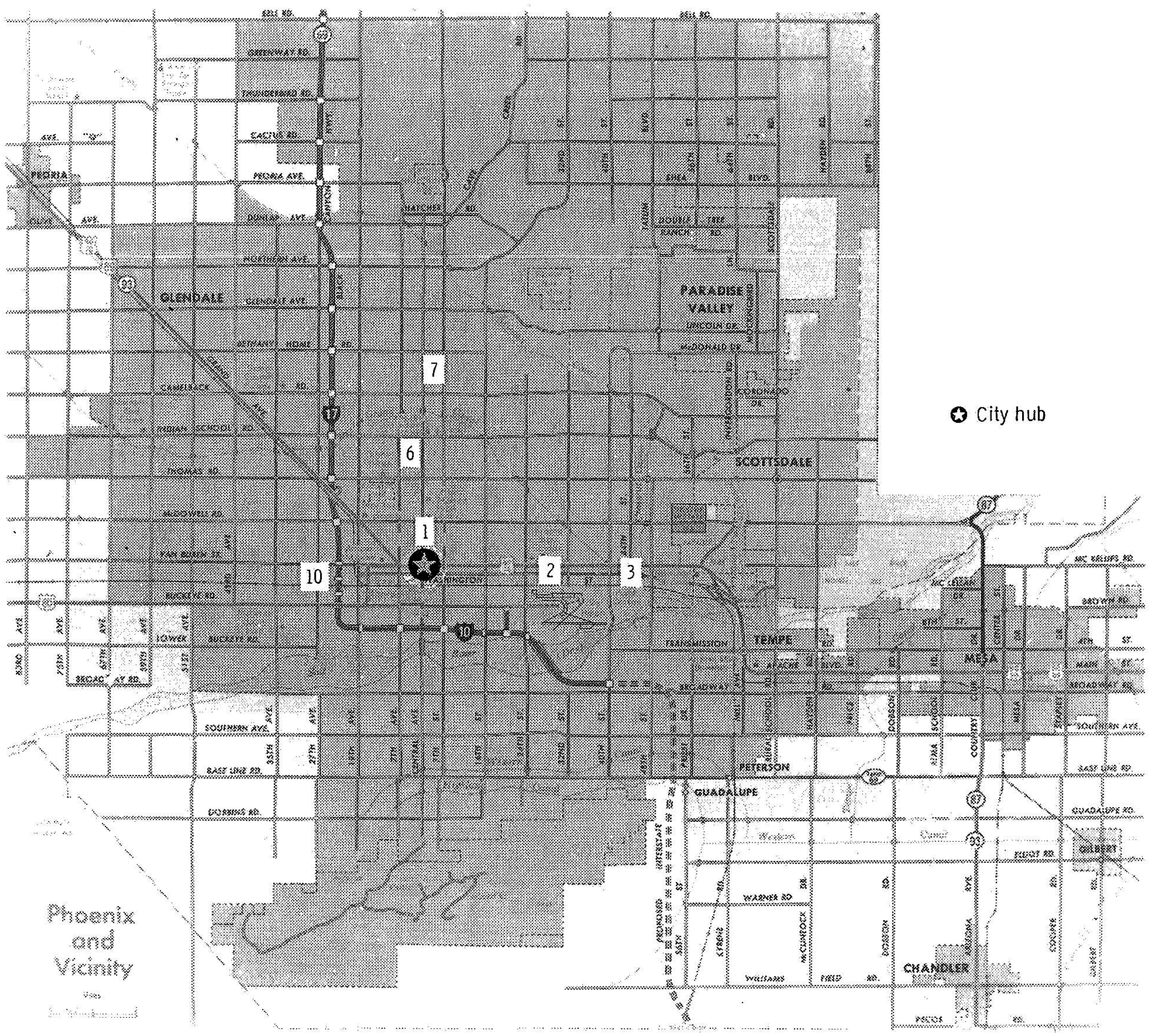


Figure 2. - Map showing ground measuring sites 1, 2, 3, 6, 7, and 10 for noise survey. (From ref. 1.)

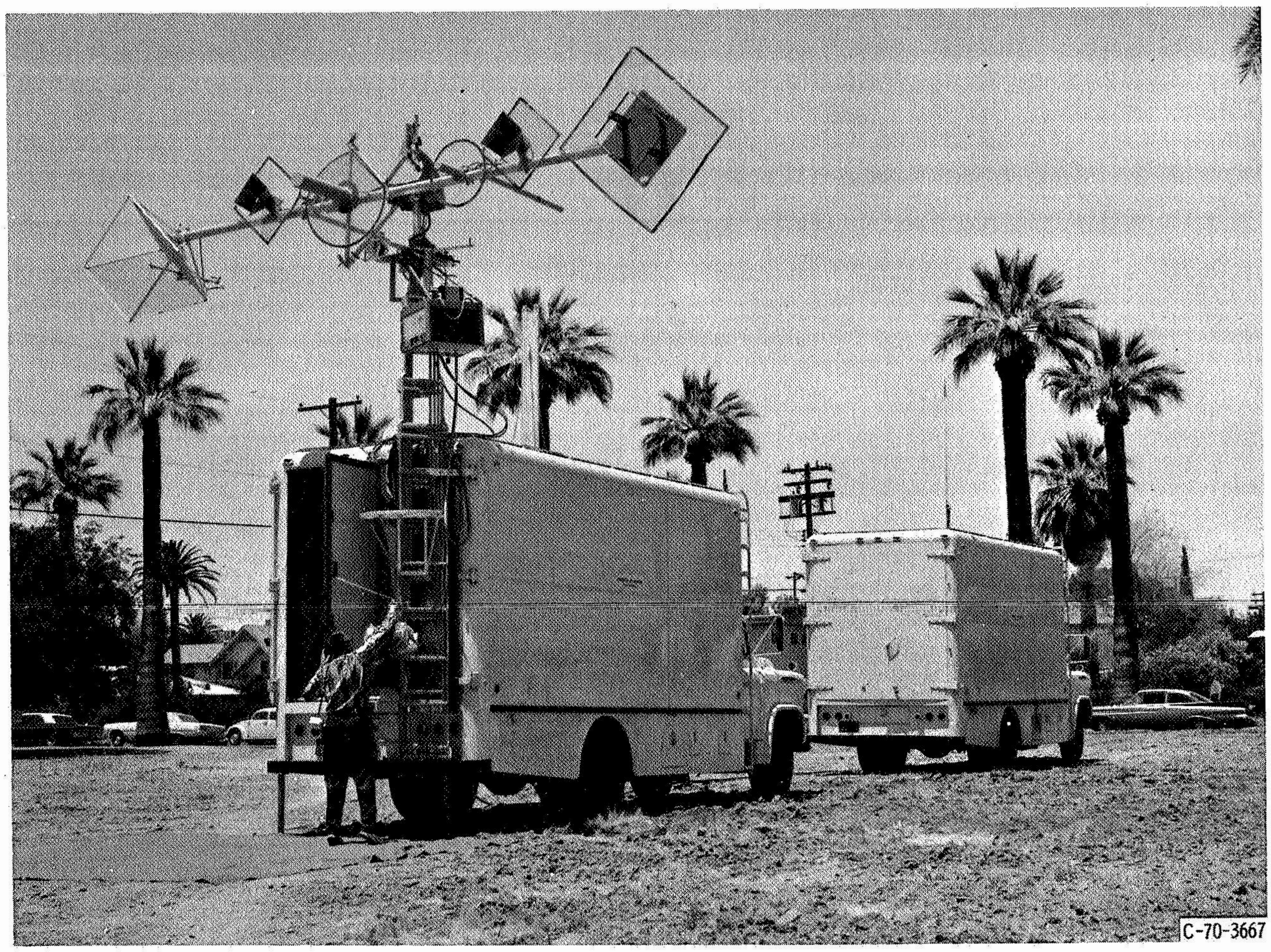


Figure 3. - Typical recording site. (From ref. 1.)

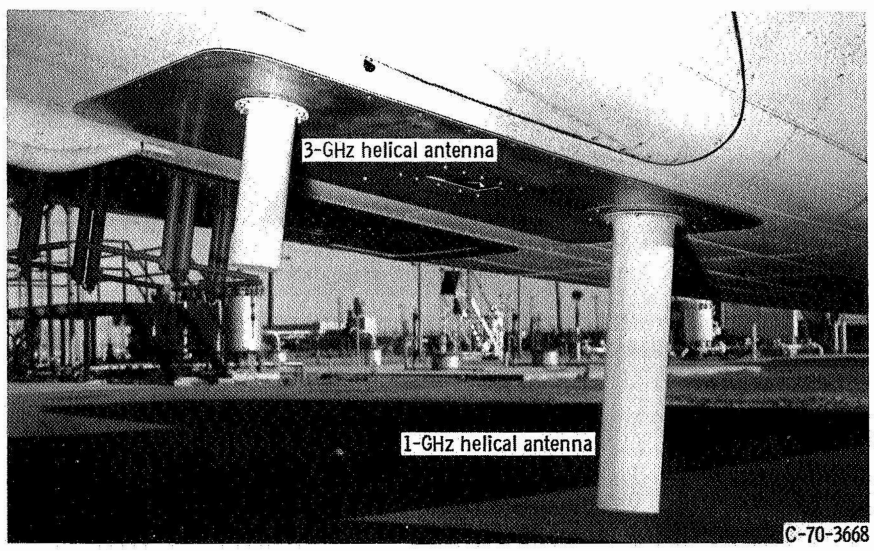


Figure 4. - Helical antenna mounted under aircraft fuselage. (From ref. 1.)

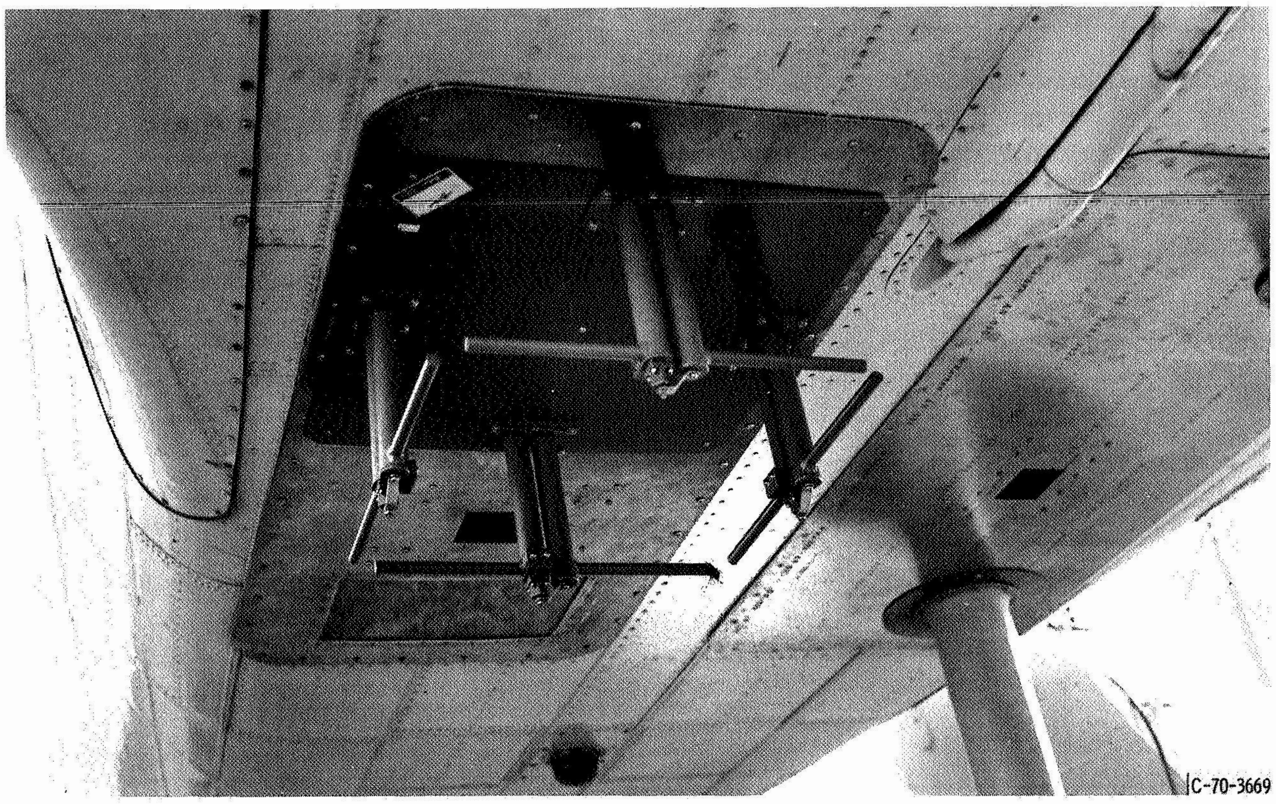


Figure 5. - Circular polarized 300-megahertz antenna mounted underneath fuselage. (From ref. 1.)

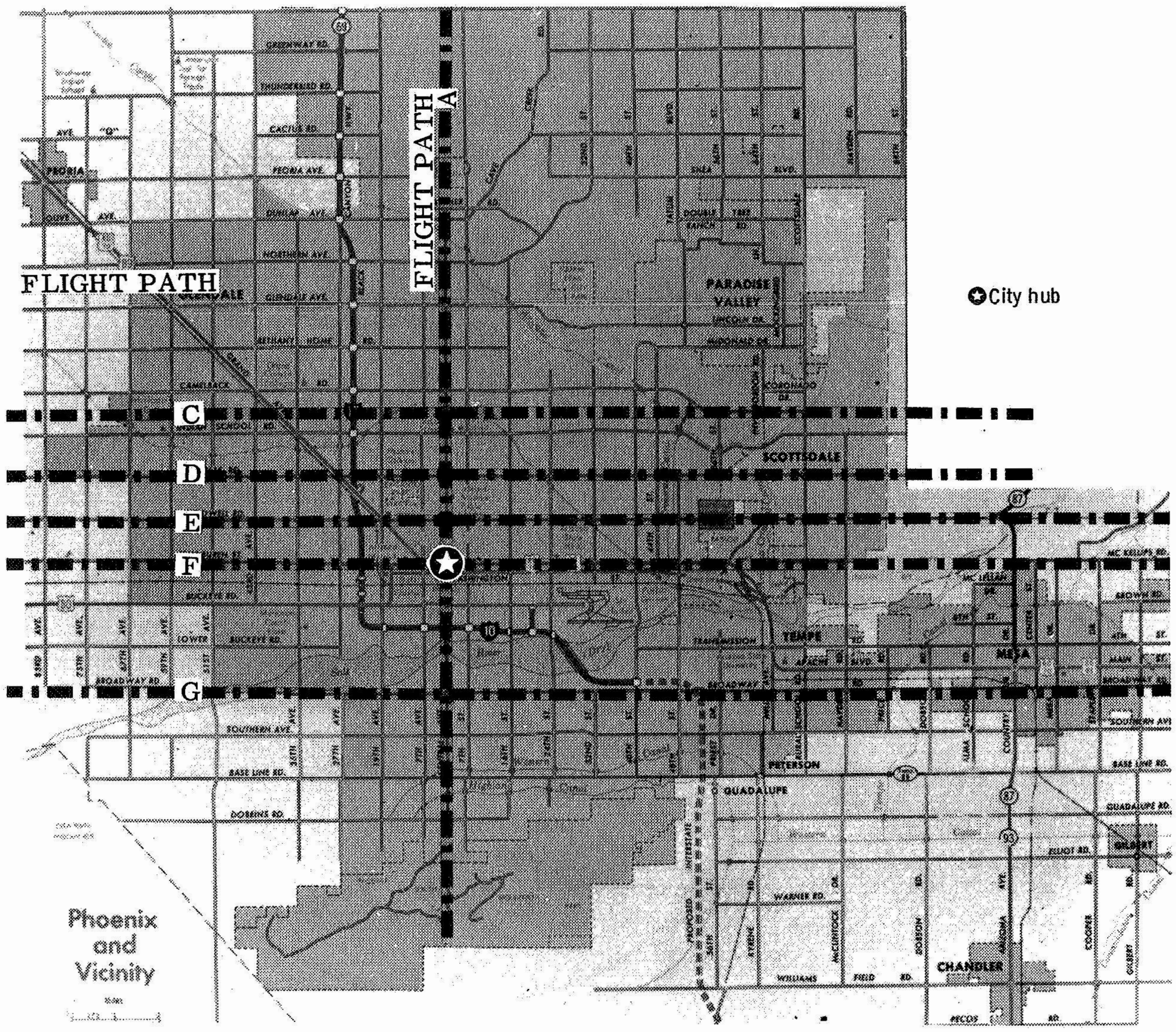


Figure 6. - Map showing flightpaths. (From ref. 1.)

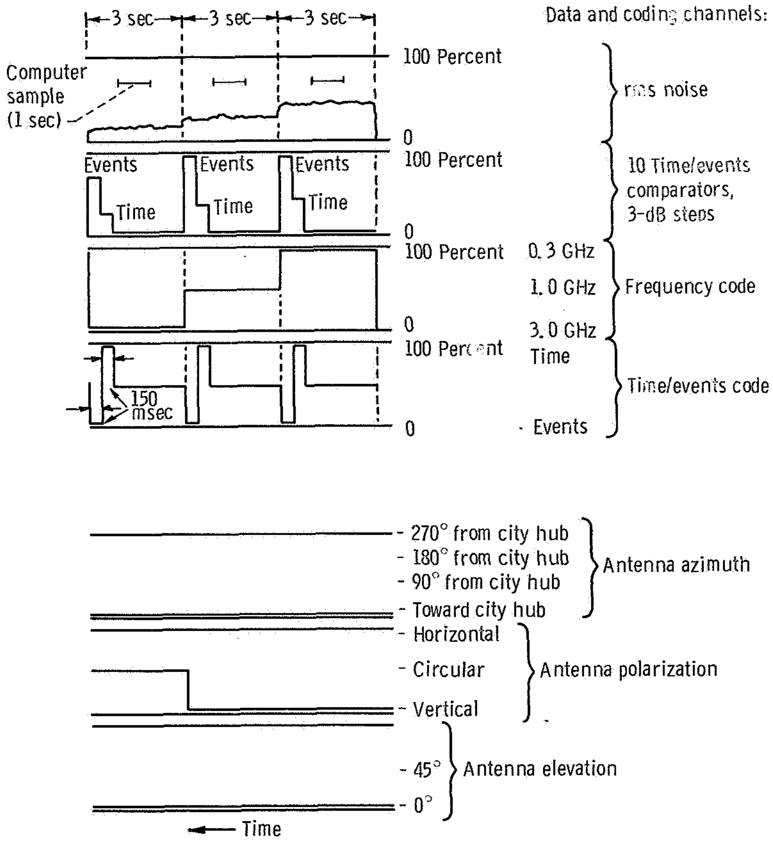
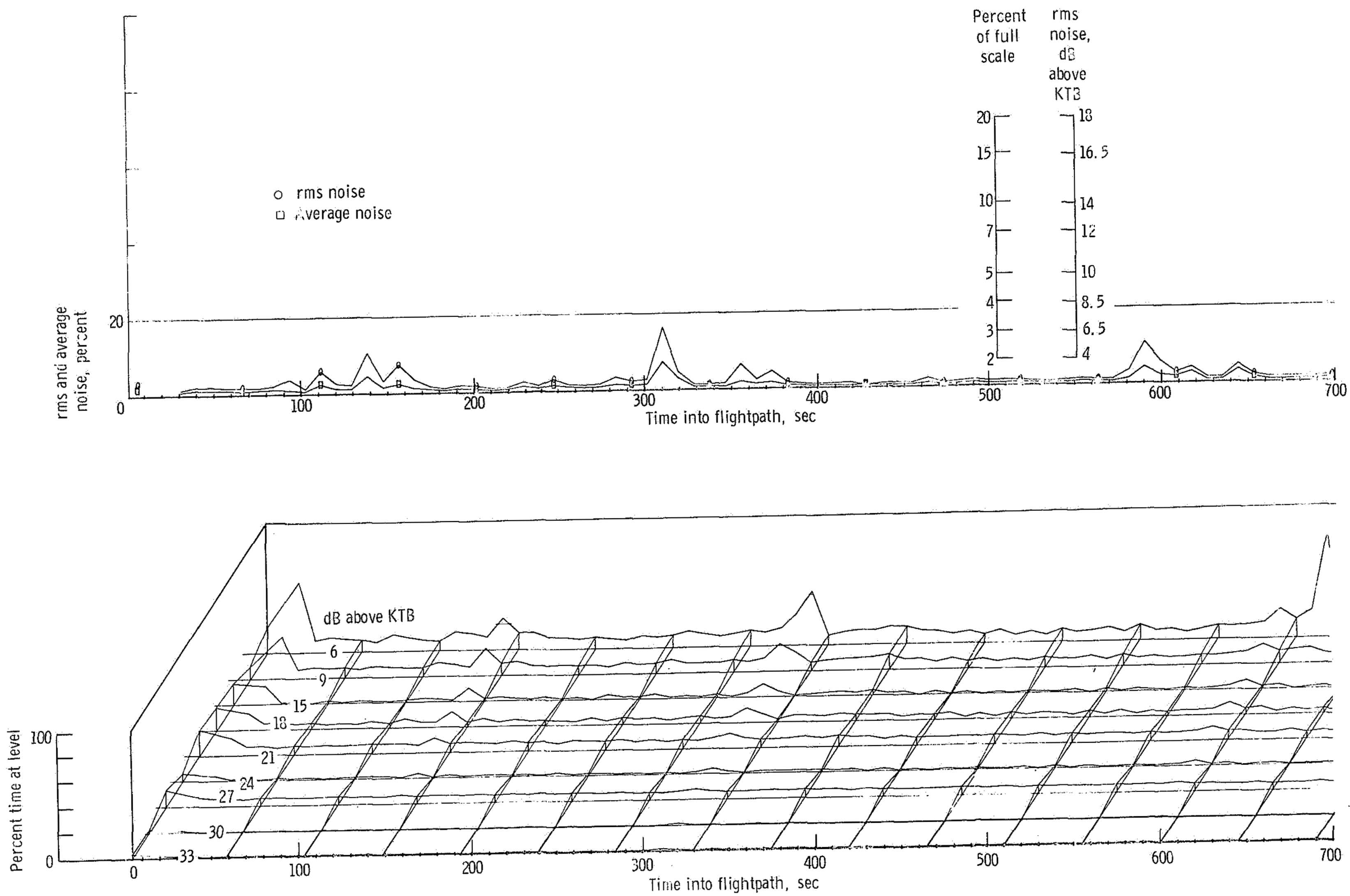
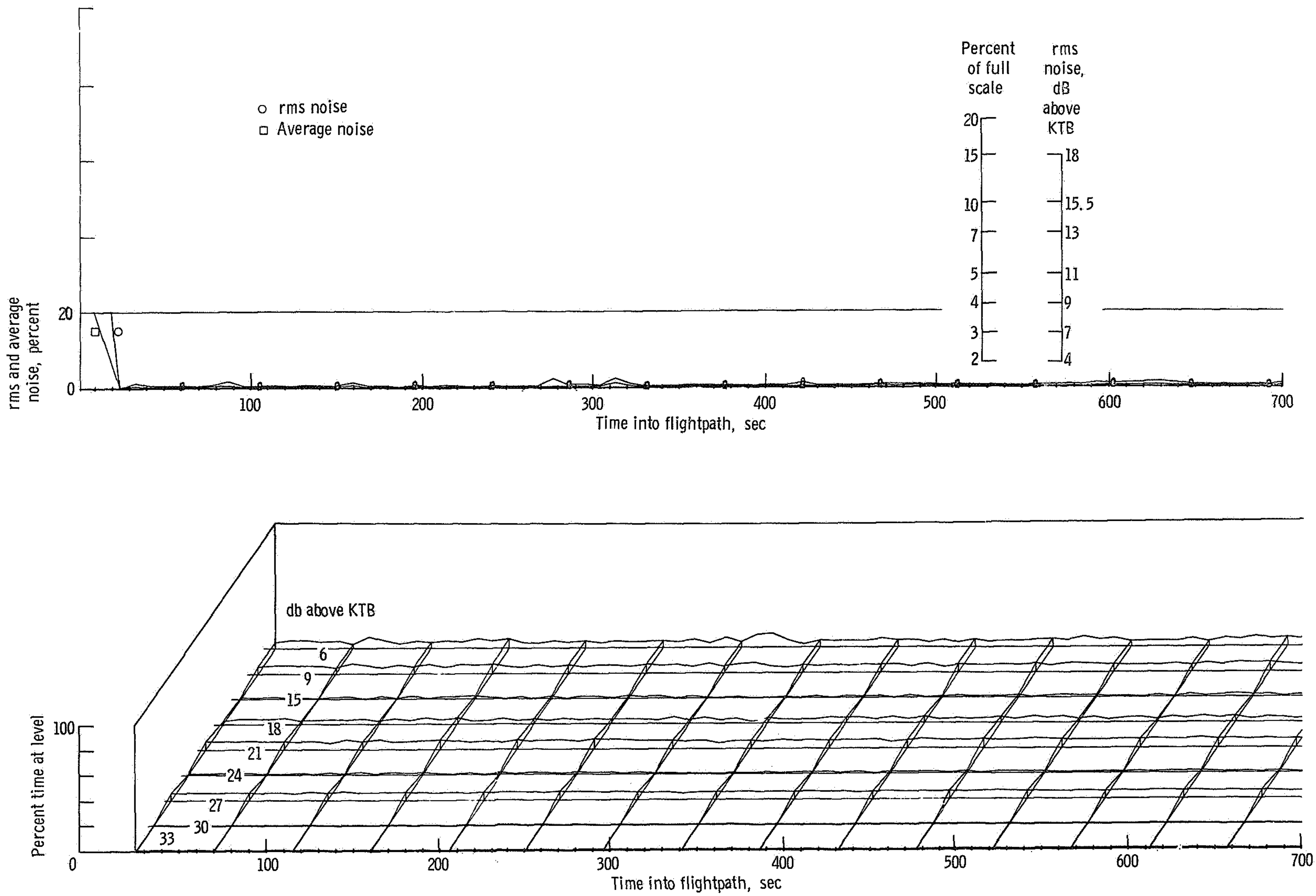


Figure 7. - Radiofrequency noise data recording format.



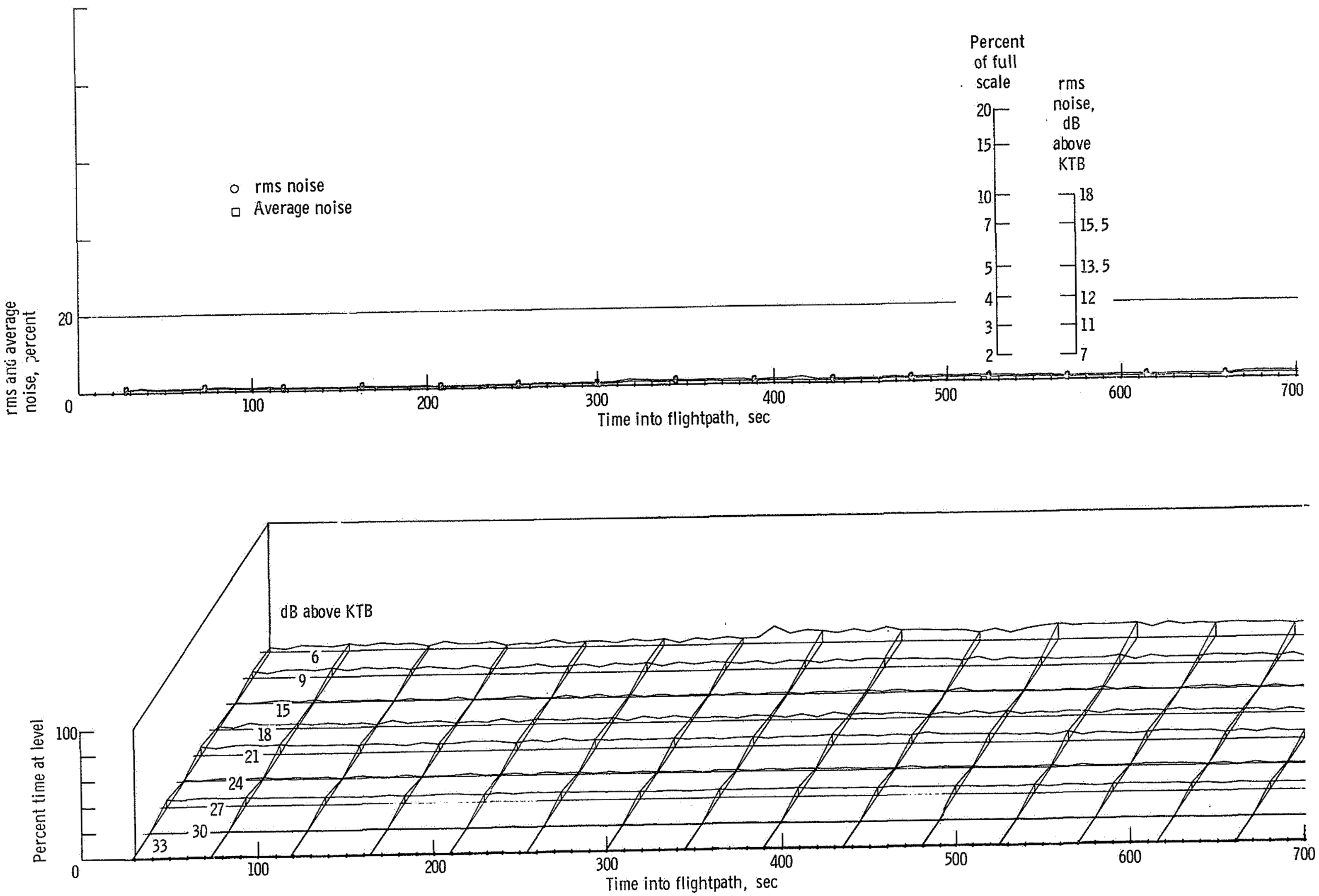
(a) Frequency, 0.3 gigahertz.

Figure 8. - Microfilm noise data, site 10; rms noise, average noise, and time comparator data; 0630 hours, May 14, 1968.



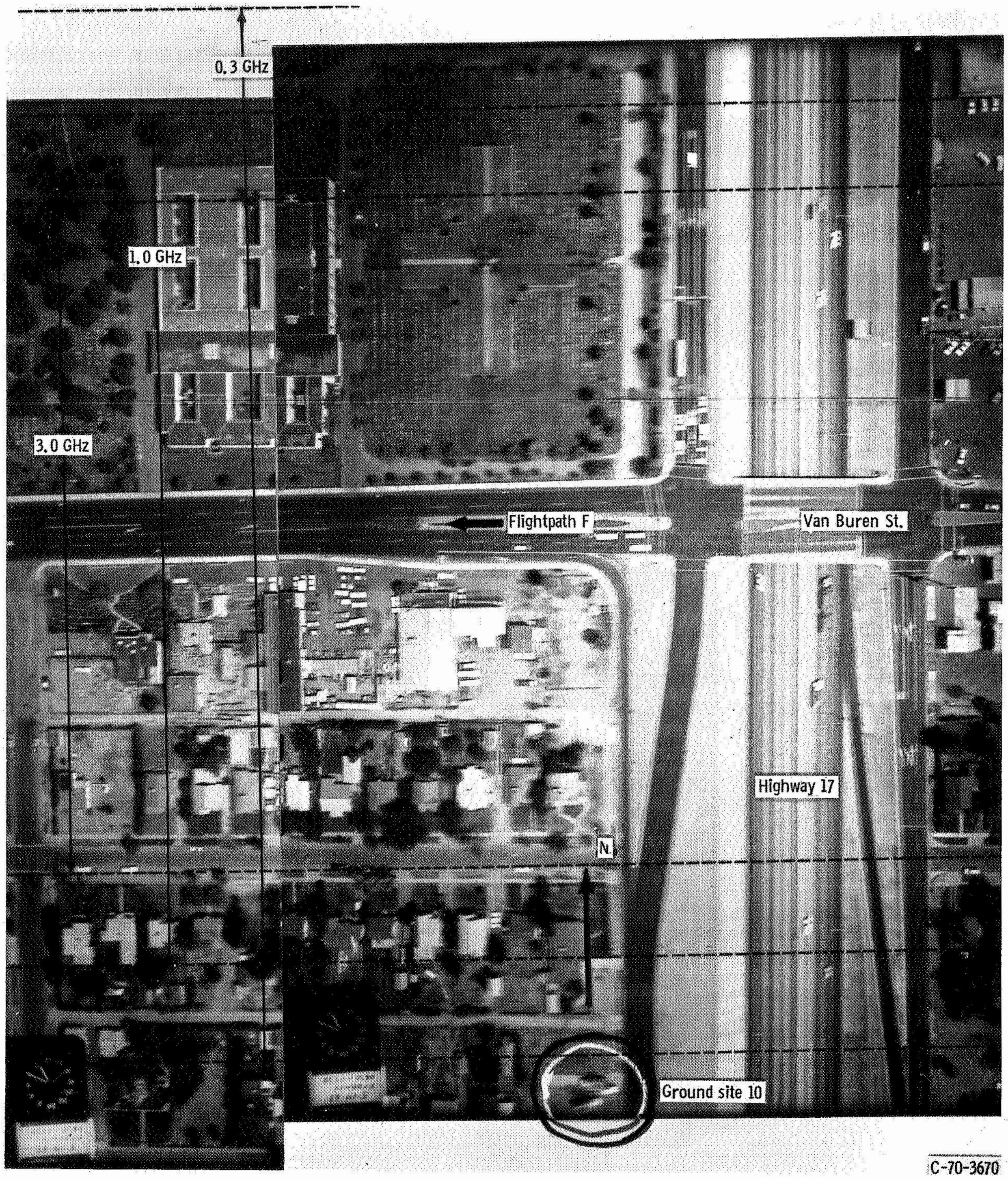
(b) Frequency, 1.0 gigahertz.

Figure 8. - Continued.



(c) Frequency, 3.0 gigahertz.

Figure 8. - Concluded.

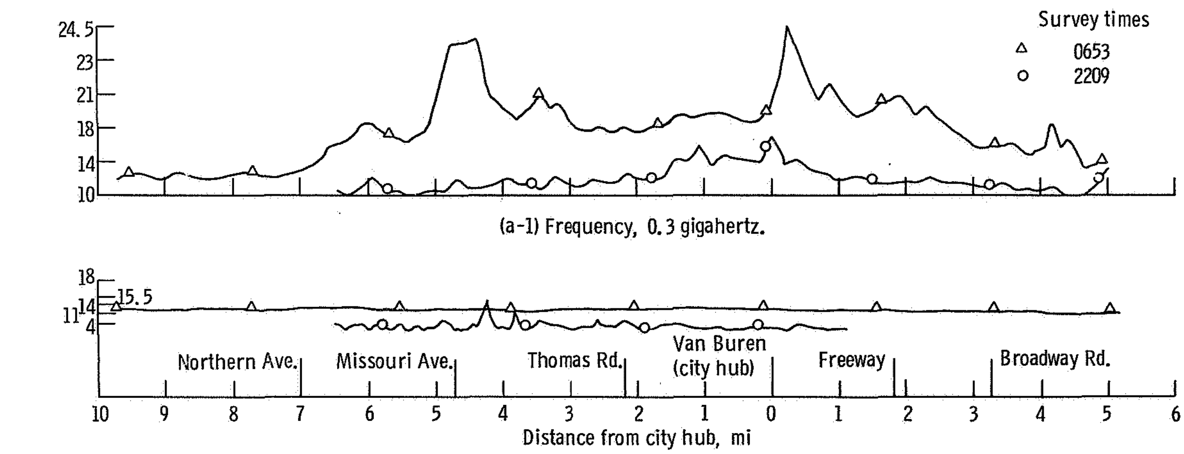


(a) Altitude, 1000 feet (305 m); flightpath F.

Figure 9. - Ground area covered by airborne antennas.

(b) Altitude, 4000 feet (1220 m); flightpath A.

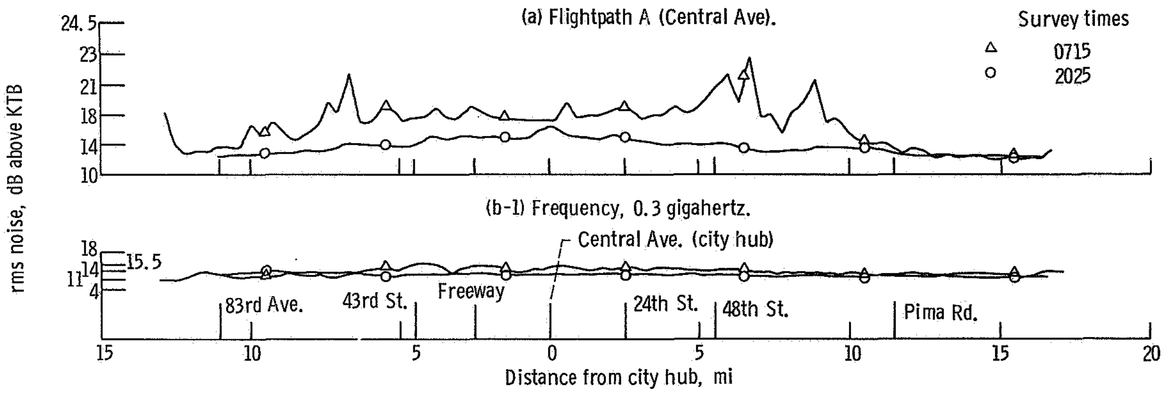
Figure 9. - Concluded.



(a-1) Frequency, 0.3 gigahertz.

(a-2) Frequency, 1.0 gigahertz.

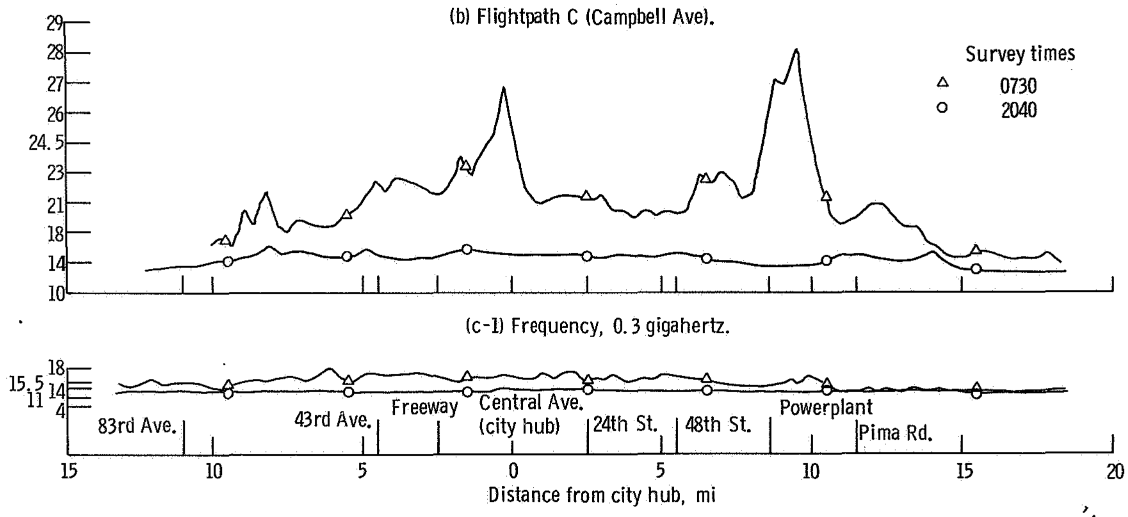
(a) Flightpath A (Central Ave).



(b-1) Frequency, 0.3 gigahertz.

(b-2) Frequency, 1.0 gigahertz.

(b) Flightpath C (Campbell Ave).

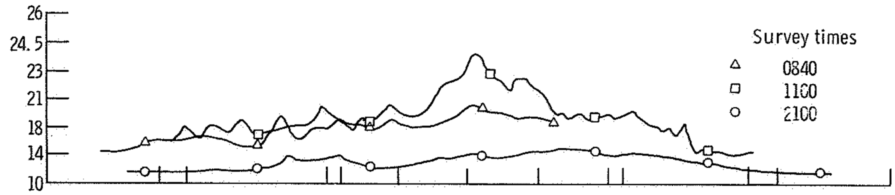


(c-1) Frequency, 0.3 gigahertz.

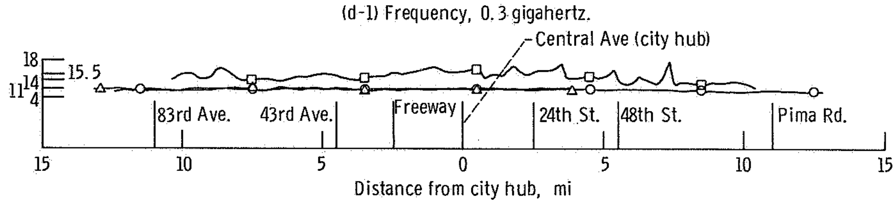
(c-2) Frequency, 1.0 gigahertz.

(c) Flightpath D (Thomas Rd.)

Figure 10. - rms noise; altitude, 4000 feet (1220 m).

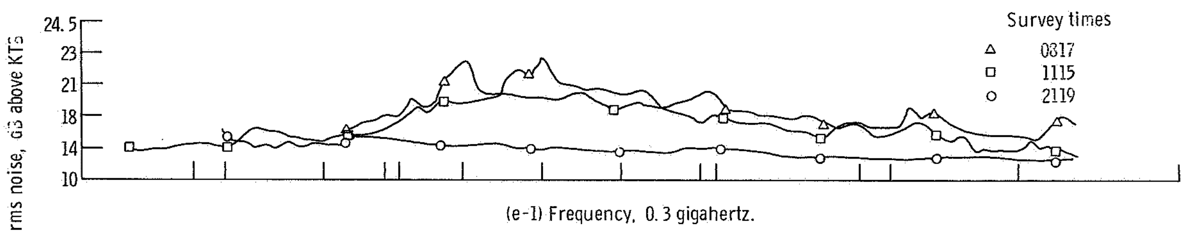


(d-1) Frequency, 0.3 gigahertz.

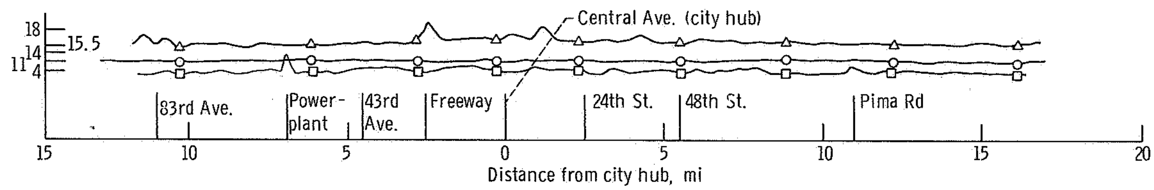


(d-2) Frequency, 1.0 gigahertz.

(d) Flightpath E (McDowell Rd).

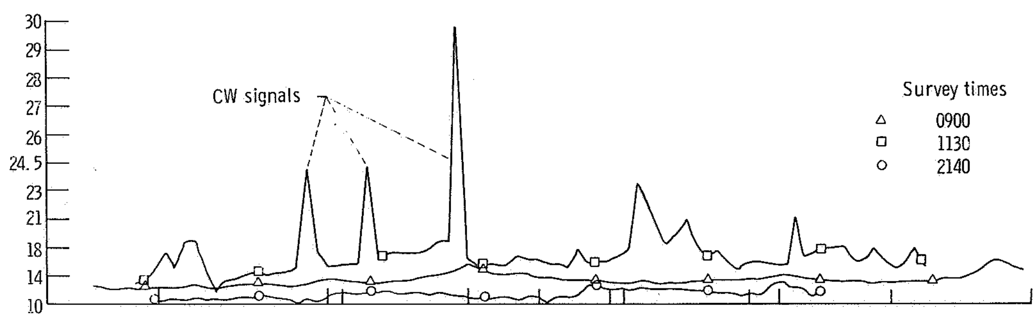


(e-1) Frequency, 0.3 gigahertz.

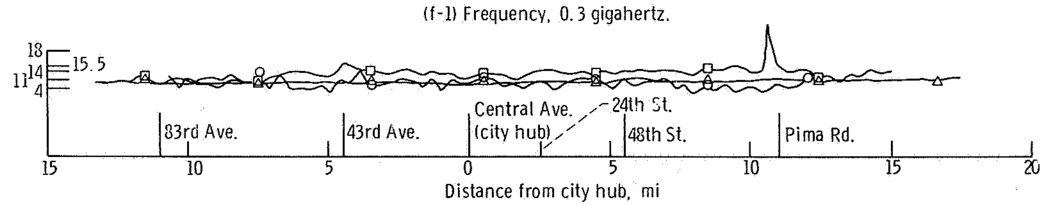


(e-2) Frequency, 1.0 gigahertz.

(e) Flightpath F (Van Buren St.)



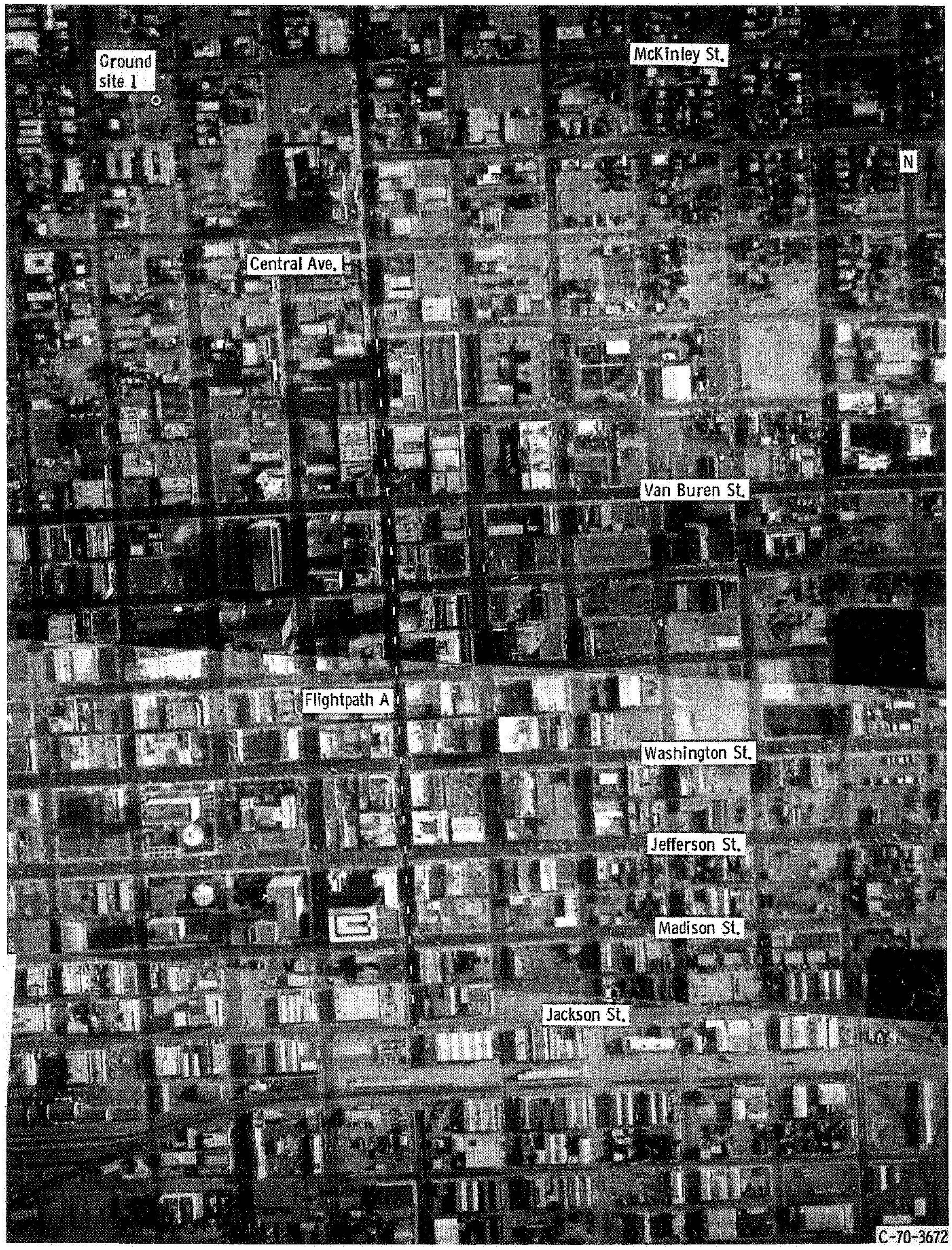
(f-1) Frequency, 0.3 gigahertz.



(f-2) Frequency, 1.0 gigahertz.

(f) Flightpath G (Broadway Ave.).

Figure 10. - Concluded.

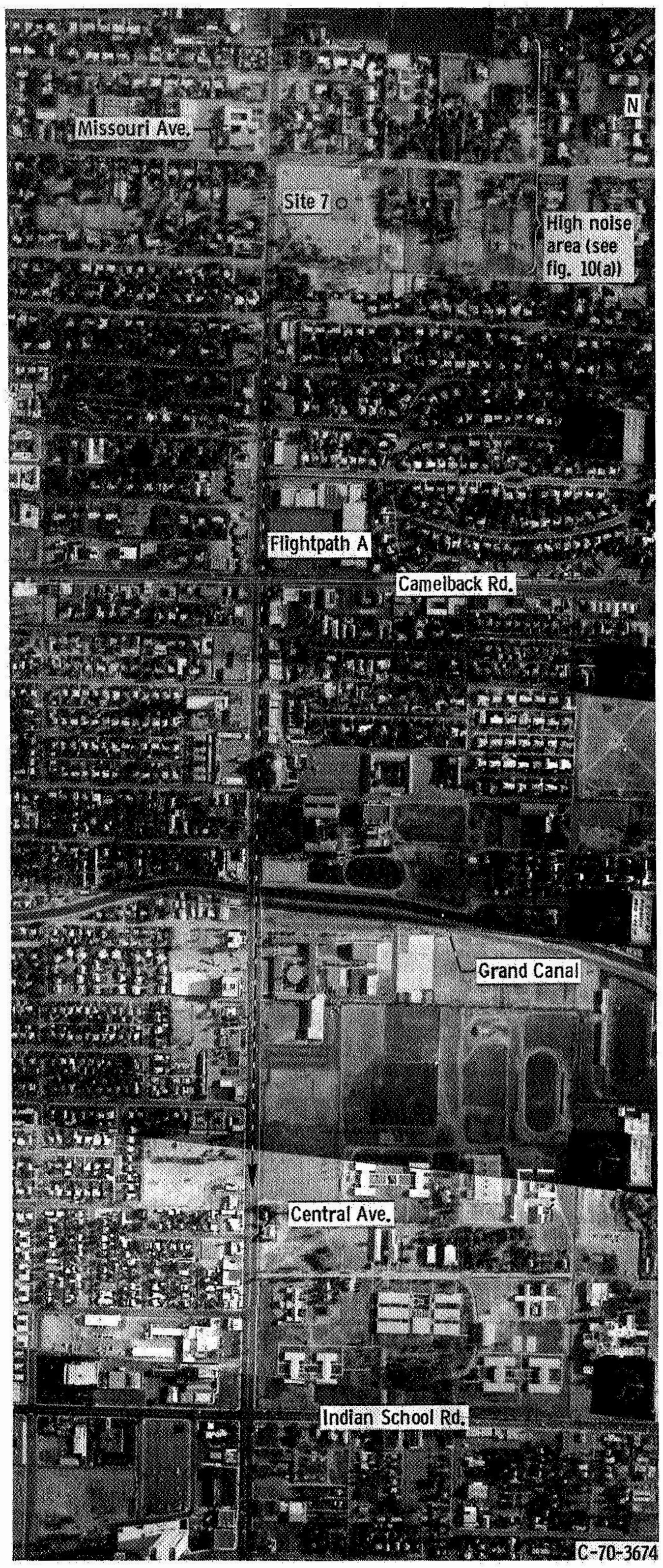


(a) Flightpath A. High noise area, downtown.

Figure 11. - Combined aerial photographs of high noise areas. Altitude, 4000 feet (1220 m).

(b) Flightpath D. High noise area, powerplant.

Figure 11. - Continued.



(c) Flightpath A.

Figure 11. - Concluded.

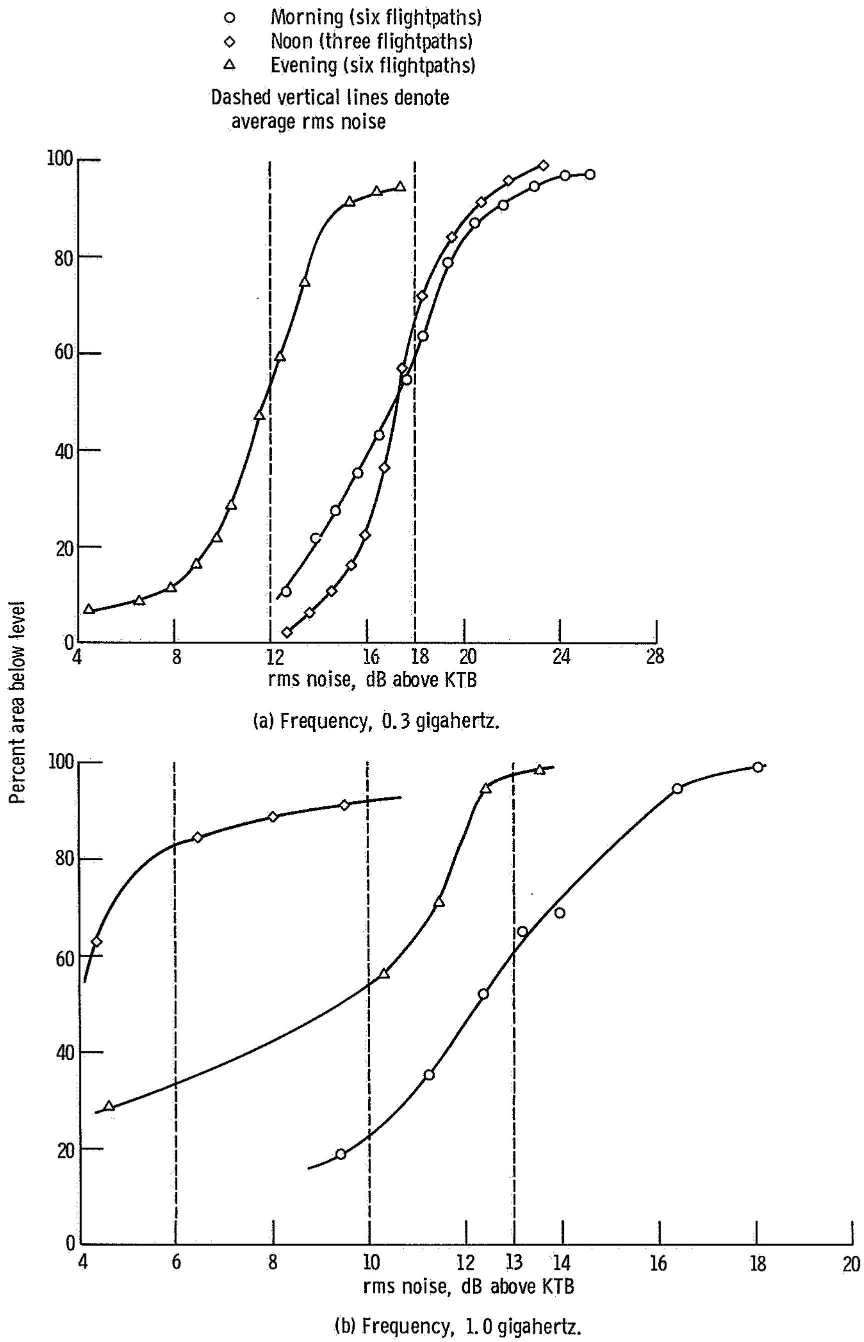
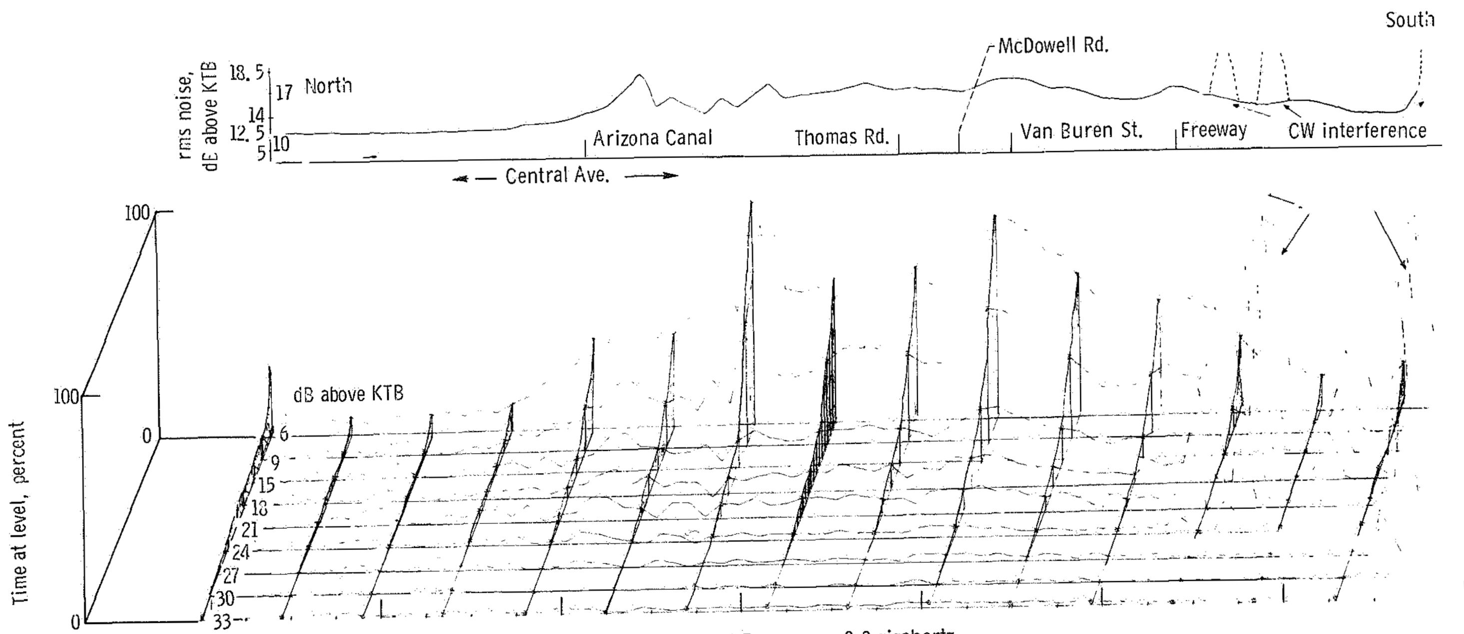
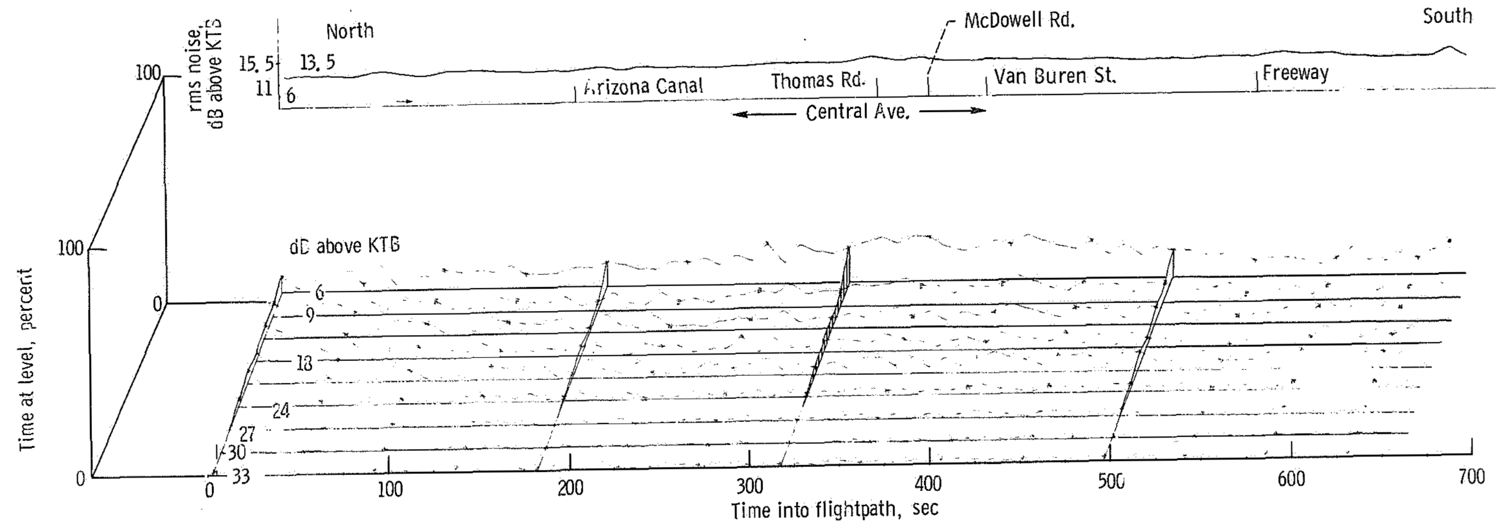


Figure 12. - rms noise probability distribution. Altitude, 4000 feet (1220 m).

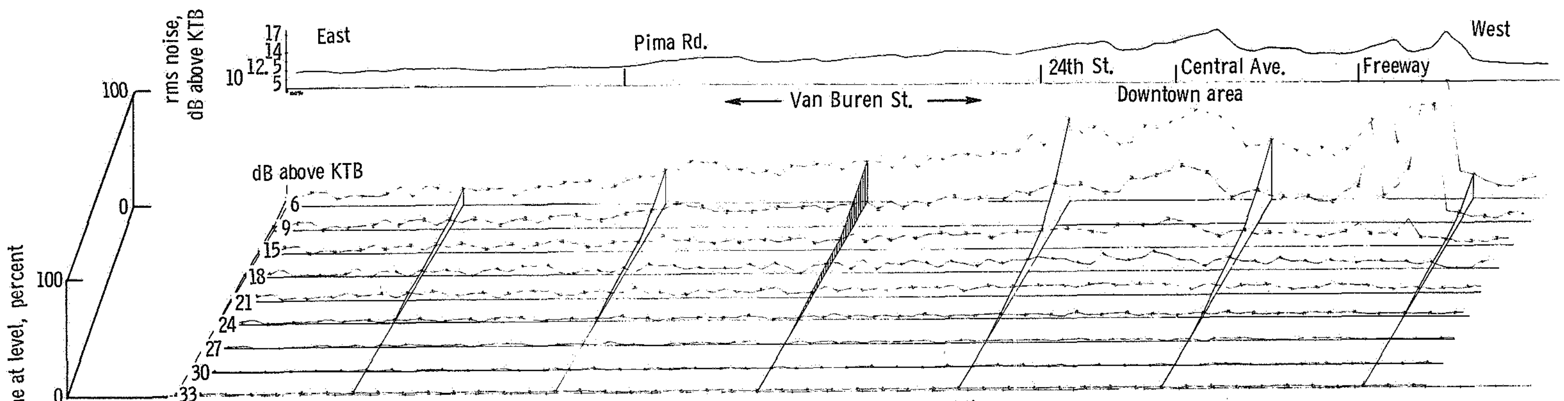


(a) Frequency, 0.3 gigahertz.

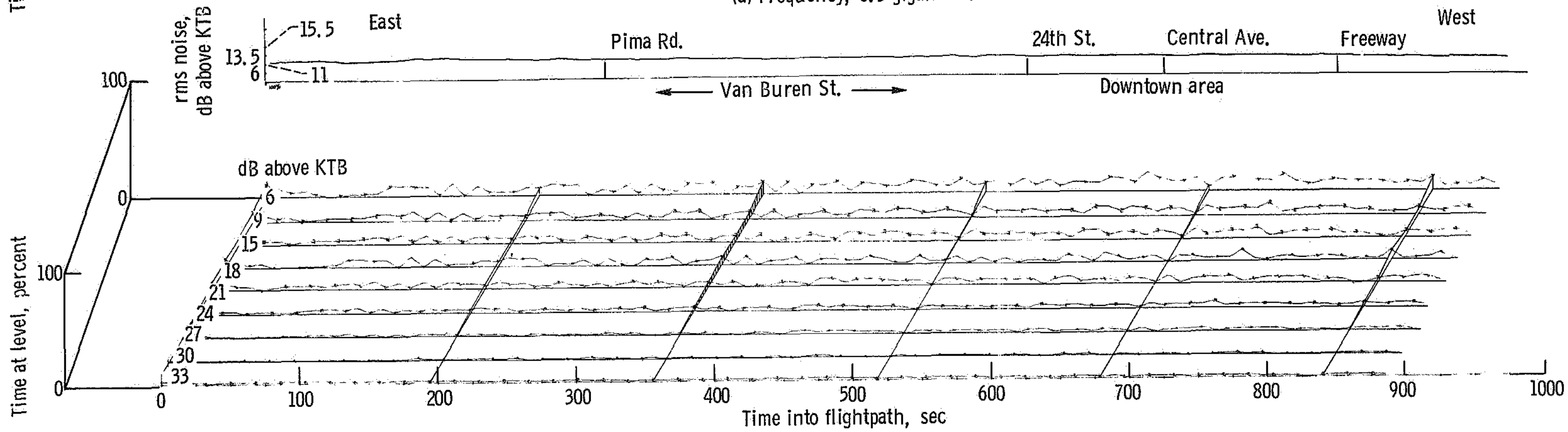


(b) Frequency, 1.0 gigahertz.

Figure 13. - rms noise and time comparator data, flightpath A. Time, 2000 hours; altitude, 4000 feet (1220 m).

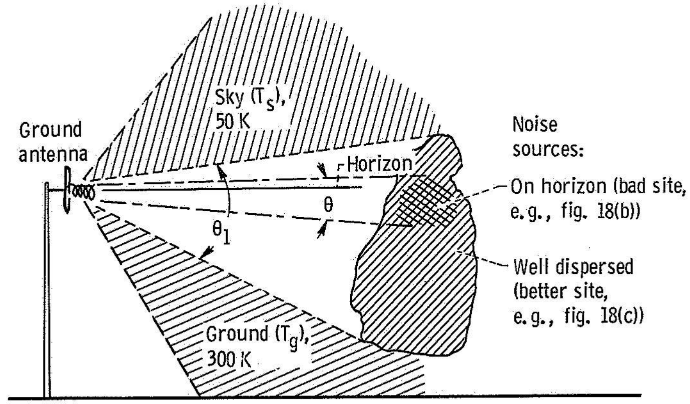


(a) Frequency, 0.3 gigahertz.

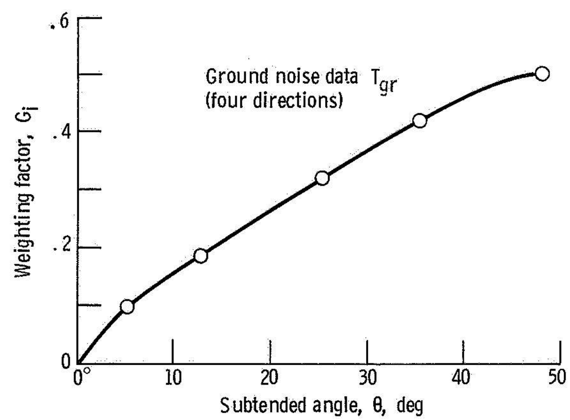


(b) Frequency, 1.0 gigahertz.

Figure 14. - rms noise and time comparator data, flightpath F. Time, 2100 hours; altitude, 4000 feet (1220 m).

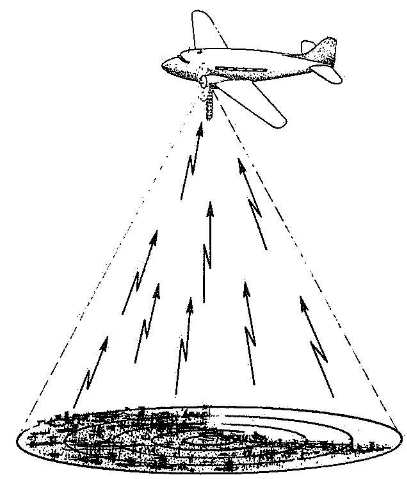


(a) Air-ground noise correlation, ground noise data, $T_{gr} = 0.5(T_s + T_g) + G_i(T_i) + T_r$.

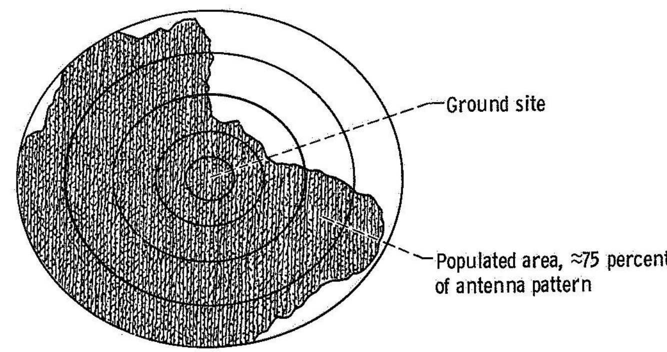


(b) Weighting factor G_i (correction from site photographs), 0.3 gigahertz.

Figure 15. - Simultaneous air and ground radiofrequency noise survey - air-ground noise and weighting factor for ground system.

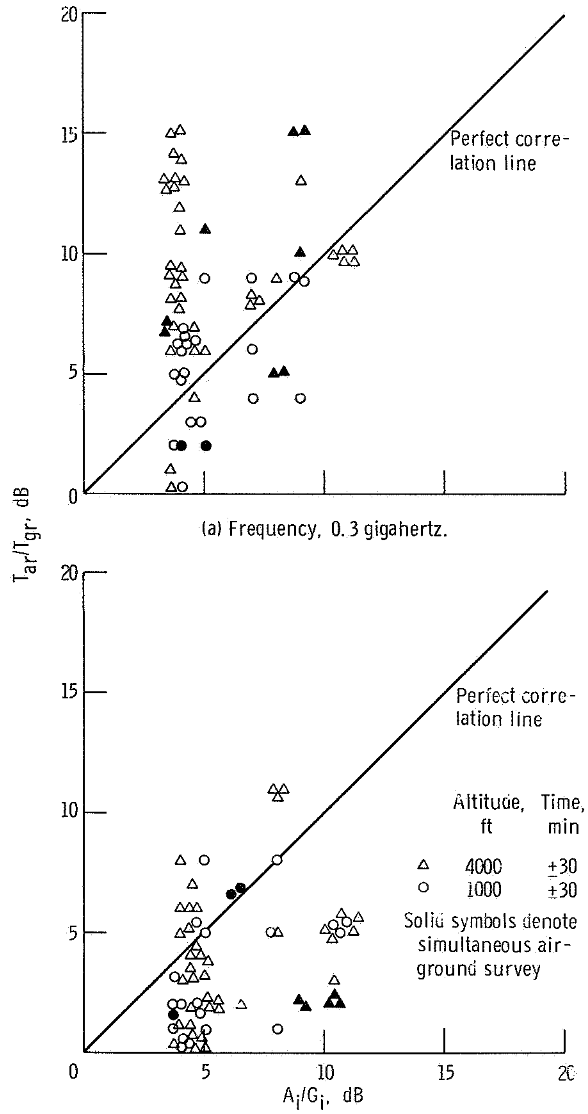


(a) Air-ground noise correlation, airborne noise data, $T_{ar} = 1(T_g) + A_iT_i + T_r$.



(b) Weighting factor A_i (correction from city map and photographs).

Figure 16. - Simultaneous air and ground radiofrequency noise survey - air-ground noise correlation and weighting factor for airborne system.

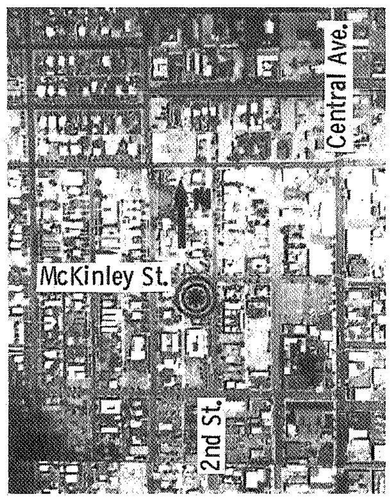


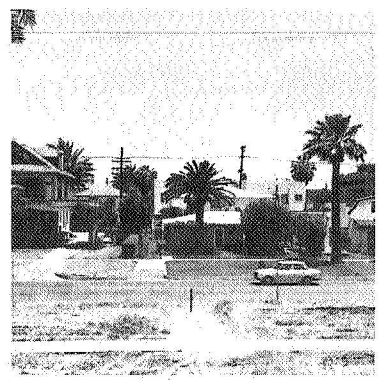
(b) Frequency, 1.0 gigahertz.

Figure 17. - Air-ground correlation, five ground sites.

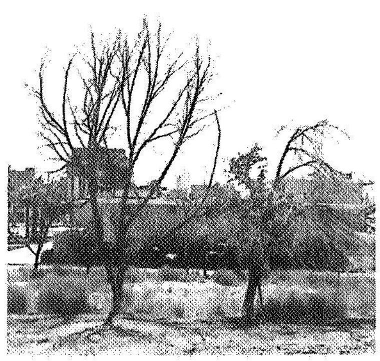
North, $\theta \approx 40°$

West, $\theta \approx 45°$





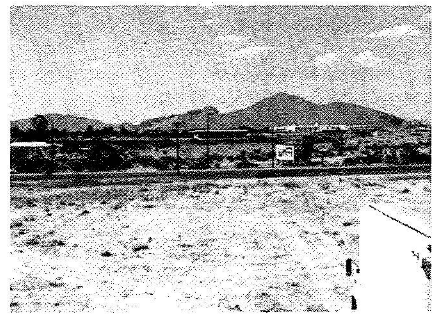
East, $\theta \approx 45°$



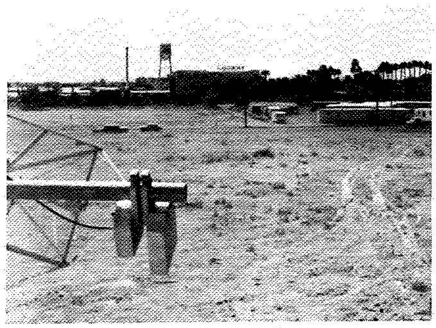
South, $\theta \approx 45°$

(a) Site 1, McKinley St. and North 2nd St.

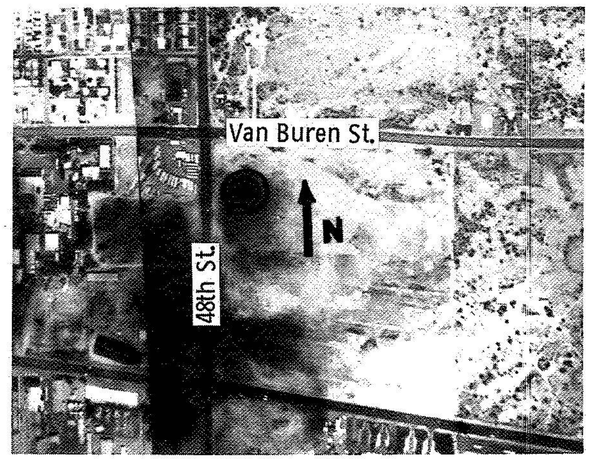
Figure 18. - Aerial and ground photography used for site definition.

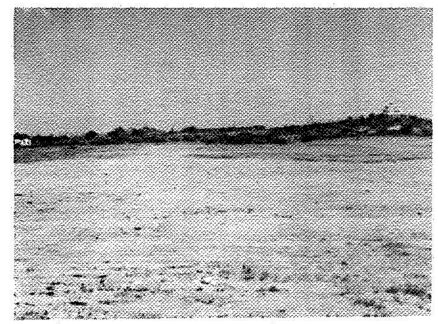


North, $\theta \approx 10^\circ$

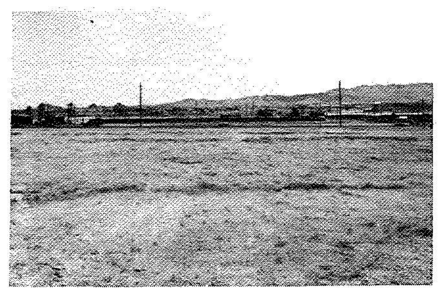


West, $\theta \approx 10^\circ$





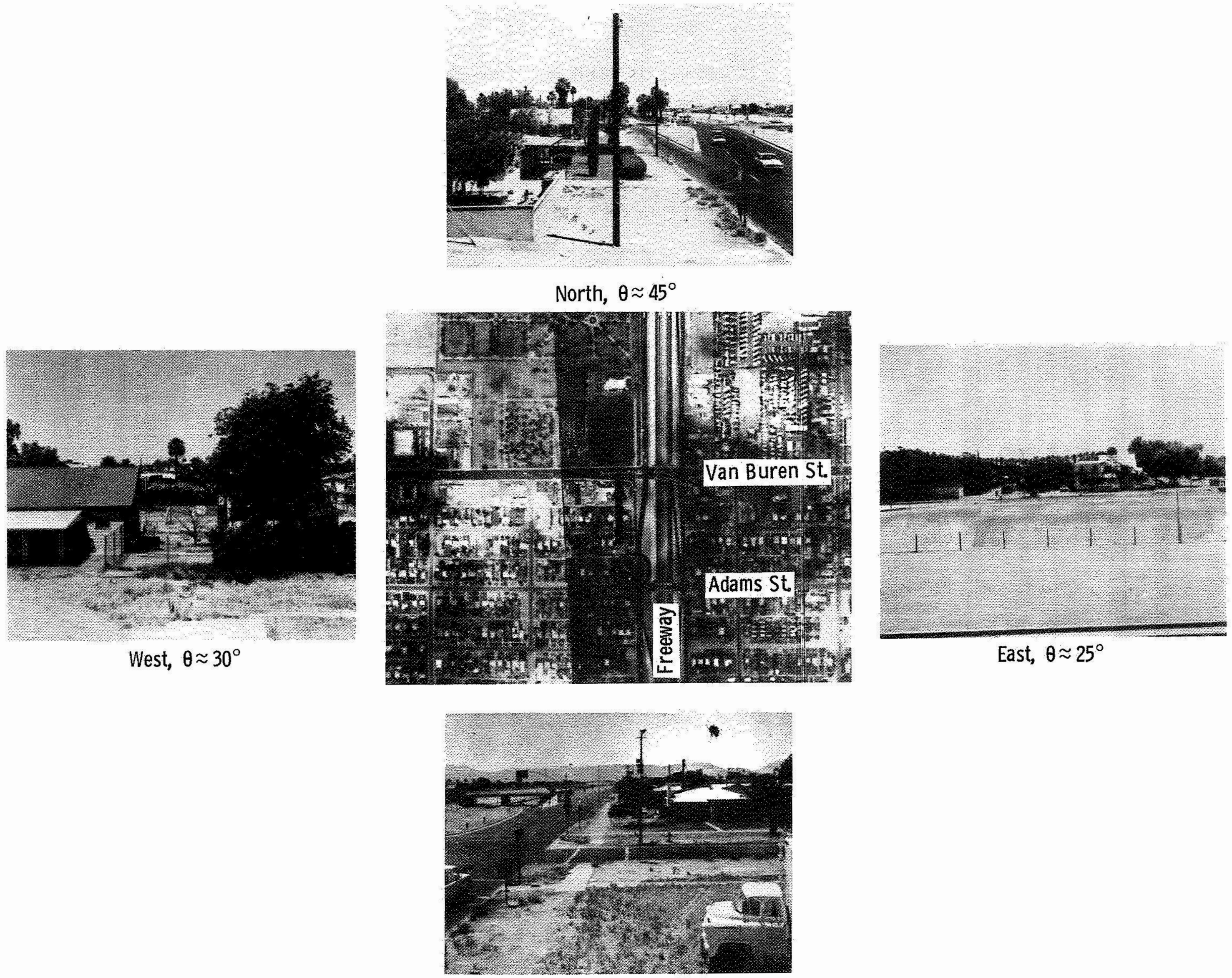
East, $\theta \approx 5^\circ$



South, $\theta \approx 5^\circ$

(b) Site 3, VanBuren St. and 48th St.

Figure 18. - Continued.



(c) Site 10, Adams St. and Freeway.

Figure 18. - Concluded.

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